MONTGOMERY COUNTY
FIRE AND RESCUE COMMISSION

THE EFFECTS OF SPEED HUMPS AND TRAFFIC CIRCLES ON RESPONDING FIRE-RESCUE APPARATUS IN MONTGOMERY COUNTY, MARYLAND

TESTS CONDUCTED JOINTLY BY
THE FIRE AND RESCUE COMMISSION AND
DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION
WITH ASSISTANCE PROVIDED BY:

Department of Fire and Rescue Services
Montgomery County Police Department
Cabin John Park Volunteer Fire Department
Hillandale Volunteer Fire Department
Bethesda Fire Department

AUGUST 1997

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EXECUTIVE SUMMARY

Due to their concern for the alleged adverse effects of speed humps and traffic circles on fire-rescue response, the Montgomery County Fire and Rescue Commission, at its October 10, 1996 meeting, passed two motions concerning this issue: 1) that field tests be conducted to quantify and analyze the effect of speed humps and traffic circles on response times; 2) that the Department of Public Works and Transportation provide these test results to the public when applications for speed humps and traffic circles are submitted to them. These motions came about as the result of concerns of how speed humps and traffic circles adversely affect response times, and they were based upon the results of speed hump and traffic circle tests conducted in Portland, Oregon and Austin, Texas where quantitative data showed significant delays for fire-rescue apparatus.

On April 30, 1997, the Fire and Rescue Commission (FRC) and Department of Public Works and Transportation (DPWT), with assistance from other local fire-rescue and police organizations, conducted field tests of fire-rescue apparatus traversing speed humps and traffic circles of the types typically found throughout Montgomery County. Two courses were utilized for this purpose, one having three[1] 12-ft Watts-type speed humps and the other having a single traffic circle. Twelve test runs were conducted on each course, featuring four types of apparatus (i.e., engine, tiller-style ladder truck, aerial tower, ambulance) and three different drivers per vehicle. The test runs were timed and the results compared to calculated times for courses of similar distances without speed humps and traffic circles in order to determine delays attributed to these devices.

The results of the Montgomery County speed hump and traffic circle tests confirmed that these two types of traffic calming devices cause delays for fire-rescue vehicles en route to incidents. The amount of delay was found to be dependent upon three factors -- vehicle type/size, type of traffic calming device, and driver discretion regarding speed.

On the speed hump course, where the units were attempting to maintain a constant speed of 25 mph, the average impact delay per hump was found to range between a high of 7.3 seconds for the Ladder Truck and a low of 2.8 seconds for the Aerial Tower. The higher delay is equivalent to responding from a station .05 mile per speed hump further away from the incident location along an unimpeded route. More importantly, the four vehicles averaged slightly less than 20 mph across the speed hump test route, about half the response cruising speed of 35-40 mph typically attained by fire-rescue vehicles on unimpeded roads. Should speed hump-impeded routes taken by responding units limit average speed to 20 mph, the amount of area they can serve within 5

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[1] Multiple speed humps spaced over short distances are commonplace in the County.

minutes[2] may drop to 1.3 linear miles (equivalent to 6.8 sq. mi. surrounding the station) versus the 2.0 linear miles (16 sq. mi.) served within 5 minutes along unimpeded routes whereby a cruising speed of 35-40 mph is attainable.

On the traffic circle course, where the units were attempting to maintain a constant speed of 35 mph, the average delay ranged between a high of 7.0 seconds for the Ladder Truck and a low of 3.2 seconds for the Ambulance. Similar to the speed hump test results, the higher delay is equivalent to responding from a station about .05 mile per traffic circle further away from the incident location along a route free of traffic circles. Of greater importance, the four test vehicles averaged slightly less than 28 mph on the traffic circle test course, about 7-12 mph less than the response cruising speed of 35-40 mph attained on unimpeded roads.

It is important to emphasize that these TCD tests were conducted at speeds appropriate for the two test courses, but somewhat slower than the typical response cruising speed (i.e., 35-40 mph) of fire-rescue apparatus. If similar tests were conducted in Montgomery County at speeds approaching 40 mph, greater delays would be expected, as indicated by the results of the Portland and Austin tests. The Montgomery County test results could, therefore, be considered as representing minimum delays that one would expect for responding fire-rescue vehicles in the County.

The Montgomery County tests results, in combination with those of the Portland and Austin tests, confirm that speed humps and traffic circles cause considerable delays for responding fire-rescue apparatus, which may adversely impact the outcome of certain life-threatening incidents such as those involving cardiac arrest, uncontrolled bleeding, or persons trapped in burning buildings or vehicles. Delays of this nature must be given serious attention by the public and government officials who determine the employment and specific placement of speed humps and traffic circles in their communities and jurisdictions. Those in favor of these devices must be willing to accept the likely probability of slower fire-rescue service delivery in their community and neighborhoods. While speed humps and traffic circles offer a cost-efficient approach to reducing vehicular speed and reducing the number of traffic accidents in neighborhoods, they present the disadvantage of slowing fire-rescue vehicles.

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[2] 5-minutes represents a response time goal, unadopted in Montgomery County, which assumes 1.5 minutes for dispatch, turnout, and acceleration of units up to response cruising speed; and 3.5 minutes for travel time once cruising speed has been attained.

THE EFFECTS OF SPEED HUMPS AND TRAFFIC CIRCLES ON RESPONDING FIRE-RESCUE APPARATUS IN MONTGOMERY COUNTY

INTRODUCTION

While traffic calming devices[3] have proven effective in slowing traffic, reducing the number of vehicular accidents, and discouraging motorists from cutting through residential neighborhoods, some types have also been found to cause significant delays to responding fire-rescue apparatus. Recent studies conducted in Portland, Oregon and Austin, Texas provide quantitative data as verification (see Appendix K). With the increasing presence of traffic calming devices, primarily speed humps and traffic circles, throughout Montgomery County[4], the Montgomery County Fire and Rescue Commission identified an urgent need to address speed hump/traffic circle-impact on fire-rescue vehicles responding to emergencies in the county.

On October 10, 1996, the Fire and Rescue Commission (FRC) formulated an official position concerning traffic calming devices by passing the following two motions:

> ".... that traffic calming devices (such as speed humps, speed bumps, traffic circles, etc.) can significantly increase the response time of emergency apparatus; and that the Department of Public Works and Transportation clearly notify the public of this position when applications for such devices are submitted."
>
> ".... that the Commission request the Department of Public Works and Transportation to participate with the Department of Fire and Rescue Services in developing a field test to quantify and analyze the effect of traffic calming devices on response times."

In order for the Department of Public Works and Transportation (DPWT) to provide notification to the public as stated in the first motion, the field tests called for in the second motion were

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[3] Traffic calming devices refer to a group of devices placed in and along roadways for the purpose of slowing traffic and increasing pedestrian safety. These devices include, but are not limited to, speed humps, traffic circles, curb extensions, rumble strips, edge lines, and pedestrian refuge islands.

[4] Through FY97, the County had installed close to 1100 speed humps on about 275 County-owned roadways and more are expected in FY98 and beyond. In addition, speed bumps (designed to slow all vehicles to nearly a full stop) are increasingly being installed on private roadways and parking facilities by property owners.

clearly needed. The purpose of the field tests would be to obtain locally-generated, quantitative data that would serve to verify test results found in Portland and Austin. The Fire and Rescue Commission believed that local test results, as well as findings from the Portland and Austin studies, would prove useful to County officials and residents who must weigh the positive and negative aspects of speed humps and traffic circles when contemplating their widespread usage and specific placement.

Based upon this premise, the FRC and DPWT jointly designed, planned and made preparations for a series of field tests to determine response time delays attributable to speed humps and traffic circles. A set of test objectives were established (see below) as well as test site criteria (see Appendix A) to assist in the selection of suitable sites. With one test criterion calling for dry pavement, the planning team decided to wait until Spring, 1997, to conduct the tests in order to eliminate the snow/ice factor. Mid to late-April was identified as the optimal target date (the actual test date was April 30, 1997). The planning team also established test methodology (see below), employing many of the same techniques used successfully in both the Portland and Austin studies.

TEST OBJECTIVES

By means of field testing, determine the amount of delay experienced by responding fire-rescue vehicles in traversing speed humps and traffic circles, and determine the maximum speed at which these devices can be safely traversed by these vehicles. Fire-rescue vehicles will include a range of primary units, including an engine, two types of aerial units (i.e., tiller-style ladder truck; aerial tower) and an ambulance (i.e., Freightliner type). The specific objectives:

- Determine the amount of delay caused by 12-ft "Watts" speed humps[5] (see diagram in Appendix B) and traffic circles to responding fire-rescue vehicles.

- Determine the speed at which various responding fire-rescue units can safely[6] traverse 12-ft Watts speed humps and traffic circles

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[5] A Watts speed hump is a parabolic-shaped section of raised pavement, 12 feet long in the direction of travel, and typically 3-4 inches in height at its highest (center) point. All speed humps installed on County roadways conform to the design standards accepted by the Institute of Transportation Engineers.

[6] Addresses the safety of fire-rescue personnel as well as that of patients being transported by ambulance, and the minimization of wear and tear and physical damage to the vehicle and its on-board equipment.

SCOPE OF TESTS

The speed hump and traffic circle tests conducted in Montgomery County were based upon several assumptions and constraints. While the assumptions served as the foundation upon which the tests were designed, the constraints served as boundaries to keep the scope of the project from becoming unnecessarily in-depth or beyond the capabilities of those involved. The assumptions and constraints which shaped this study are discussed below.

Assumptions

1. Speed humps and traffic circles adversely affect the response times of fire-rescue apparatus, as units must slow down to safely traverse each device along the response route.

2. The effects of speed humps and traffic circles adversely impact responding fire-rescue apparatus more so than typical automobiles driven by the public which can usually traverse these devices at speeds equal to or within 10 mph below the posted speed limit.

3. The number of speed humps and traffic circles which fire-rescue vehicles must traverse in Montgomery County are increasing. There are close to 1100 speed humps and about 50 traffic circles located on about 275 County-owned roadways, and more of such devices are expected in future years. In addition, the more severe speed "bumps" are increasingly being installed on private roadways and parking facilities by property owners.

4. A series of speed hump and traffic circle tests conducted locally will supplement the impact data made available by the cities of Portland, Oregon and Austin, Texas, both of whom have recently conducted similar tests involving fire-rescue apparatus.

5. Field tests which feature an engine, two types of aerial units (i.e., tiller-style ladder truck; aerial tower), and an ambulance will provide a representative sample of fire-rescue vehicle types and sizes on which to collect data and base conclusions.

6. Field tests which feature 12-ft Watts speed humps and traffic circles along County-owned roadways will serve as realistic worst-case tests for evaluating the impact of speed humps and traffic circles on responding fire-rescue vehicles.

Constraints

1. 22-ft flat-top speed humps, which are typically used on roadways having speed limits in the 30-35 mph range, were not evaluated in this series of tests since, due to their flat-top design, they are believed to have a somewhat lesser impact on fire-rescue response times than do the parabolic-shaped Watts humps.

2. The effect of speed humps and traffic circles upon vehicles and their on-board equipment were not studied due to the complexity of isolating hump/circle impact from that of overall wear and tear related to everyday use.

3. The effect of speed humps as it pertains to patients being transported by ambulance[7] was not studied due to the problematic logistical, legal and procedural factors associated with examining and measuring this type of impact. The use of "simulated" patients was not attempted for similar reasons.

TEST METHODOLOGY

A series of speed hump and traffic circle tests (see Appendix C) were conducted along Brickyard Road and Rock Run Drive in Potomac (see map in Appendix D) and addressed three variables:

- Vehicle type - ranging from an ambulance to a 100-ft tiller-style ladder truck
- Driver - discretionary speed chosen by each driver
- Type traffic calming device - 12-ft Watts speed hump, or traffic circle

In the process of planning and executing these tests, the following steps were completed:

1. One week prior to the planned testing schedule, flyers (see Appendix E) were distributed to residents along the test courses explaining the purpose of the tests as well as the anticipated date(s) and time(s).

2. Prior to conducting the tests, dimensions and weights of test vehicles were measured. The fully-loaded vehicles were weighed at Station 10 by Maryland State Police officers using portable scales from their highway law enforcement operation.

3. Pre-test runs (i.e., 1P, 6P) were conducted in order to identify exact positioning of Starting Points A and B and the End Point for each series of tests (diagrams appear in Appendix F). The test vehicle with the slowest acceleration rate was utilized in the pre-test runs to ensure sufficient length of all test courses.

   - Starting Point A was sufficient distance from Starting Point B to allow for acceleration of all test vehicles to the desired test speed upon reaching Starting Point B.

   - Starting Point B was sufficient distance from the first traffic calming device to allow safe, gradual deceleration of all test vehicles.

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[7] This scenario presents two issues: the impact on travel time to the hospital, and the discomfort and potential exacerbation of injury to the patient.

- The End Point was sufficient distance from the final traffic calming device to allow for acceleration of all test vehicles back to the desired speed.

4. Based on #3, Starting Points A and B and the End Point were designated with noticeable markings (i.e., traffic cone and/or chalk marking).

5. Traffic control was initiated at designated access control points in vicinity of tests. The traffic control operation was conducted by Montgomery County Police officers, with assistance provided by fire-rescue personnel. Audible and visual emergency warning systems were not used by fire-rescue vehicles during the tests since posted speed limits were not exceeded and efforts were made to minimize noise disruptions to the surrounding neighborhood. If, during a test run, a motorist unexpectedly entered the test course from a driveway and that action interfered with test results, the test would have been nullified and repeated. [A situation involving interference did not occur during testing.]

6. Each series of tests (see Appendix C) were conducted along a roadway having speed humps or traffic circles meeting test criteria (see Appendix A). Each vehicle was minimum-staffed (i.e., 3 personnel on engine, ladder truck, and aerial tower; 2 on ambulance) in order to impart realism in terms of live load and impact to personnel.

7. For each test, the following steps occurred:

   a. All participants were provided an orientation to the test site, a briefing of test procedures, and a portable radio. Drivers were provided specific instructions regarding ground rules and adherence to safety throughout test runs.

   b. All participants assumed their designated positions (see Appendix F) and monitored the designated radio channel.

   c. Upon the Starter's signal, RADAR readings began, videotaping commenced, and the designated test vehicle, from Starting Point A, accelerated (from 0 mph) to Starting Point B and crossed that point at the designated desirable speed (i.e., 25 mph[8] for speed hump course; 35 mph for traffic circle course). Upon the vehicle reaching Starting Point B, the Starter radioed the Timer/Recorders to initiate their stop watches.

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[8] 25 mph was chosen as the desirable speed for the speed hump tests based upon the following:

- 25 mph represents the typical speed limit for roadways having Watts speed humps.
- During a pre-test run by Truck 10, it was determined that speeds above 25 mph were unsafe and inappropriate for the test course (i.e., Rock Run Drive).

d. The vehicle proceeded through the test course, **traversing the speed humps, or traffic circle, at a safe, discretionary speed chosen by the driver**, and finished the test at the same designated speed[9] as when crossing Starting Point B.

e. Each Timer/Recorder positioned at a hump/circle, using a digital stop watch, recorded the time taken by the test vehicle to fully traverse the hump/circle itself from beginning to end. Timing began at the point where the front axle crossed the initial portion of the device and ended at the point where the rear axle crossed the final portion of the device.

f. The End Point Timer/Recorder, using a digital stop watch, recorded the elapsed time taken by the test vehicle to travel from Starting Point B to the End Point.

g. Throughout the test, RADAR Operators took readings as the test vehicle crossed Starting Point B, each hump/circle, and the End Point, and the RADAR Recorders recorded this data.

8. Upon completion of the tests, the following test site information was recorded:

a. Dimensions of test course and speed humps/traffic circle, and distance between test data collection points.

b. Weather and road conditions

c. Time of day that tests were conducted

RESOURCE REQUIREMENTS

In order that the tests were conducted and documented effectively, several resources were required. Resource requirements appear in Appendix G. In addition to resources provided by the Fire and Rescue Commission and Department of Public Works and Transportation, resources were also provided by the Department of Fire and Rescue Services (apparatus drivers; timers/ recorders), County Police Department (personnel and equipment), and several of the independent fire-rescue corporations[10] (apparatus; meeting location).

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[9] In some instances, test vehicles crossed the End Point at a speed slightly above or below the desired speed for the test course, which had a negligible impact on test results.

[10] Cabin John Park Volunteer Fire Department; Bethesda Fire Department; Hillandale Volunteer Fire Department

TEST DATA

Test data was recorded in the field on data sheets (blank samples provided in Appendix H) and then transferred to spreadsheets and other hardcopy formats (see Appendix I) during the data analysis phase. As described in the Test Methodology section, times were recorded for each unit as it traversed each hump/circle as well as for the entire test course. To ensure accuracy, test runs were repeated in a few instances when Timers experienced difficulties and in one case where a unit crossed the End Point at a speed which differed from the desired test speed by greater than 5 mph.

In addition to quantitative data, all test runs were videotaped to visually capture the impact of the speed humps and traffic circles upon the apparatus. Several cameras were utilized for this purpose and positioned at strategic points along the test courses. Two were set in place and operated remotely, while a third was operated by a roving cameraman.

DATA ANALYSES

The manner in which the test data is used to answer each of the test objectives is described below.

Objective 1 - Determine the amount of delay caused by Watts speed humps and traffic circles to responding fire-rescue vehicles.

The data make possible the determination of the time delay attributed to each hump/circle, per vehicle type. The impact time is the additional time required to travel the hump/circle-impeded route as compared to the **calculated time**[11] required to travel an unimpeded route of identical distance by the same vehicle. The difference between the two times indicates the delay attributed to the humps/circle. Delays associated with each hump/circle, in terms of vehicle type and desirable speed, have been calculated (see Appendix I). The data allow for comparisons between hump/circle-impact on different type/size fire-rescue vehicles.

Objective 2 - Determine the speed at which various responding fire-rescue units can safely traverse Watts speed humps and traffic circles.

RADAR readings taken during the tests indicate the discretionary speeds of the drivers as the units traversed each hump/circle. For each test, RADAR readings for Drivers A, B and C are averaged to produce a representative speed at which a given fire-rescue vehicle can safely traverse a hump or circle. The data (see Appendix I) allow for comparisons between the safe speeds at

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[11] The time required to travel an unimpeded route of identical distance was calculated rather than field tested because the desired speed on which to base hump/circle impact delays was set at a specific level, and all necessary rate conversions could be calculated on paper.

which different type/size fire-rescue vehicles traverse speed humps and traffic circles.

INTERPRETATION OF TEST RESULTS

As expected, the results of the speed hump and traffic circle tests confirm that these two types of traffic calming devices cause delays for fire-rescue vehicles en route to incidents. The amount of delay is dependent upon three factors -- vehicle type/size[12], type of device, and driver discretion regarding speed. For Watts-type speed humps, the most commonly encountered traffic calming device in the County, the average impact delay[13] per hump was found to range between a high of 7.3 seconds for Truck 10 and a low of 2.8 seconds for Aerial Tower 6, over a test course where the units were attempting to maintain a constant speed of 25 mph. For a single traffic circle, the average delay ranged between a high of 7.0 seconds for Truck 10 and a low of 3.2 seconds for Ambulance 248, over a test course where the units were attempting to maintain a constant speed of 35 mph.. The results of each type of test are examined in greater detail below.

Speed Hump Test Results

The results of the speed hump tests (see Appendix I-1), in which the units were attempting to maintain a constant speed of 25 mph, indicate that Truck 10 (T10) experienced an average impact delay of 7.3 seconds per Watts-type hump, the longest delay of any test vehicle. The average delays experienced by Engine 301 (E301), Ambulance 248 (A248), and Aerial Tower 6 (AT6) were 4.2, 3.8 and 2.8 seconds, respectively. In addition, T10 averaged only 6.1 mph while traversing the 12-ft parabolic-shaped humps themselves, about 19 mph below the desirable speed for the test course and about 29-34 mph below a typical response "cruising speed" thought to be in the 35-40 mph range.[14] Likewise, A248, E301, and AT6 averaged only 8.7, 9.1 and 10.8 mph, respectively, while traversing the 12-ft speed humps.

The impact delay of 12-ft Watts speed humps may be more easily understood if equated to distance. The chart in Appendix I-2 contains equivalent distances of this nature. Under the

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[12] Appendix J presents vehicle specifications (e.g., weight, dimensions, etc.)

[13] Impact delay refers to the full impact delay caused by a hump/circle, including the deceleration time as the unit approaches the device, the time to traverse the device itself, and the time required to accelerate back to the desired response speed.

[14] Results of a widely-accepted response time study conducted in New York City by the Rand Institute indicate that fire department apparatus travel at an average cruising speed of 39.2 mph, following the initial ½ mile of the response route when units are accelerating to that cruising speed. Similar results were replicated in urbanized municipalities elsewhere in the United States.

assumption of a 5-minute response time goal[15], the chart shows that if Truck 10 is responding at a cruising speed of 25 mph, each 12-ft hump that it traverses has the effect of placing the fire station .05 (1/20) mile further from the incident along a response route unimpeded by humps. To further this concept, the chart also reveals that every five humps have the effect of adding approximately 1/4 mile to the equivalent response distance. Stated alternatively, five humps have the effect of needing to move the fire station 1/4 mile closer to the incident in order to maintain a 5-minute response goal. Similar comparisons are presented for the other test vehicles traveling at 25 mph.

More importantly, the four vehicles averaged slightly less than 20 mph across the test route, about half of the 35-40 mph response cruising speed typically attained by fire-rescue vehicles on roads unimpeded by speed humps. Assuming that speed hump spacing along the test course is representative of hump installations county-wide, fire-rescue apparatus will frequently be limited to a 20 mph response cruising speed on hump-impeded routes.

Should speed hump-impeded routes taken by responding units limit average speed to 20 mph, the amount of area they can serve within 5 minutes may drop to the area within 1.3 linear miles[16] from the station versus the area within 2.0 linear miles served within 5 minutes along unimpeded routes upon which a cruising speed of 35-40 mph is attainable. Coverage of 1.3 miles in each direction from a station would be about 6.8 square miles per station for a total of 210 square miles covered by the County's 31 fire-rescue stations[17]. In comparison, coverage of 2.0 miles in each direction would equal 16 square miles per station for a total of 496 square miles[18] covered by the same 31 stations. Assuming the 1.3 mile scenario, station coverage would be 42% of that available from stations unimpeded by speed humps, implying that 58% of the residents/service recipients would wait more than 5 minutes for service after calling 911.

Whether stated in terms of a time delay or an equivalent distance, speed humps along a response route will slow fire-rescue units -- the amount of delay dependent upon the number of humps, type of apparatus, and the discretionary speed of the driver. In the case of a citizen experiencing a life-threatening medical emergency (e.g., cardiac arrest, uncontrolled bleeding, anaphylactic shock,) or entrapment in a burning building or vehicle, these delays may adversely affect timely assistance required of responding fire-rescue units, with serious consequences a possibility. For

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[15] 5-minutes represents a response time goal, unadopted in Montgomery County, which assumes 1.5 minutes for dispatch, turnout, and acceleration of units up to response cruising speed; and 3.5 minutes for travel time once cruising speed has been attained.

[16] Linear mileage refers to the straight line distance **in each direction** from the station.

[17] Figure does not include the two rescue stations (equipped with EMS/rescue units but lacking fire suppression units) whose first-due response areas overlap those of the 31 fire and rescue stations which provide fire, rescue and EMS services to the county.

[18] Figure equal to the total area within Montgomery County.

example, when a person goes into cardiac arrest, their best chance for survival is when an automatic external defibrillator is applied, or CPR is initiated, within 6 minutes[19] of the occurrence of cardiac arrest. Their chances for survival decrease steadily beyond the initial 6 minutes.

It is important to emphasize that these speed hump tests were conducted at a speed of 25 mph, an appropriate speed for the Rock Run Drive test course, but considerably slower than the typical cruising speed (35-40 mph) of fire-rescue apparatus. If similar tests were conducted in Montgomery County at speeds closer to this range, greater delays would be expected. Results of the speed hump tests conducted in Portland, Oregon and Austin, Texas (see Appendix K) support this supposition, where, for example, delays exceeded 9 seconds per hump in the Portland tests for larger vehicles traveling at 40 mph. The Montgomery County test results could, therefore, be considered as representing minimum delays that one would expect for fire-rescue vehicles responding along a speed hump-impeded route within the county.

Traffic Circles

The results of the traffic circle tests (see Appendix I-3), where the units were attempting to maintain a constant speed of **35** mph, indicate that T10 experienced an average impact delay of 7.0 seconds regarding the single-circle test, the longest delay of any test vehicle. The impact delays experienced by AT6, E301, and A248 were 5.4, 5.0 and 3.2 seconds, respectively. In addition, T10 and AT6 averaged only 10.3 mph while traversing the circle, about 25 mph below the desirable speed for the test course and about 30 mph below a "cruising speed" 40 mph. Likewise, A248 and E301 averaged only 14.0 mph, respectively, while traversing the circle, also far below both the desired speed and cruising speed.

Of greater importance, the four vehicles averaged slightly less than 28 mph across the test course, about 7-12 mph less than the response cruising speed of 35-40 mph generally attainable on roadways unimpeded by traffic circles. Considering that traffic circles are much less prevalent in Montgomery County than speed humps[20], it is unlikely that fire-rescue apparatus will be frequently limited to a 28 mph response cruising speed due to traffic circles alone; however, for roadways containing a mixture of both circles and humps, response speeds may well be limited to the 20-28 mph range[21].

It is important to emphasize that these traffic circle tests were conducted at a speed of 35 mph, an appropriate speed for the Brickyard Road test course and within the typical 35-40 mph cruising speed range referenced above. Portland also conducted traffic circle tests (see Appendix K), at speeds between 25 and 40 mph. Since Portland's results for 35 mph were comparable (slightly

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[19] As recommended by the American Heart Association

[20] The present ratio of humps to circles is about 22:1.

[21] The 20-28 mph range incorporates the reduced speeds associated with each type of traffic calming device tested -- Watts humps and traffic circles, respectively.

higher on average) to those found in Montgomery County, it is believed that the Portland results[22] for tests run at 25, 30 and 40 mph would be applicable in Montgomery County, as well. Under this supposition, impact delays could approach 8-10 seconds per traffic circle for larger fire-rescue vehicles (e.g., T10) responding at 40 mph along Montgomery County roadways.

As is the case with speed humps, traffic circles along a response route will slow fire-rescue units -- the amount of delay dependent upon the number of circles, type of apparatus, and the discretionary speed of the driver. These delays may adversely affect timely assistance required of responding fire-rescue units, with serious consequences possible in the case of life-threatening emergencies.

RECOMMENDATIONS

As a result of the speed hump and traffic circle tests described above, the following recommendations are offered by the Fire and Rescue Commission and Department of Public Works and Transportation:

1. The results of this study be made available by the Department of Public Works and Transportation to any County resident or community organization who approaches DPWT concerning the installation of speed humps and traffic circles in their neighborhoods. These test results should be made available in the form of either this report or a condensed format approved by both the FRC and DPWT. A community pursuing speed hump/traffic circle installation will then have the appropriate information at hand to make an informed decision. Should they choose hump/circle installation, the community will be, in essence, accepting the fact that fire-rescue units will require greater time to reach locations in their neighborhood.

2. DPWT continue to notify the local fire-rescue corporation of any request for speed hump or traffic circle installation in their first-due area so that the corporation is given the opportunity to discuss their concerns with the originating party prior to DPWT approval of installation.

3. The issues and results contained in this report be addressed in the upcoming evaluation of the County's Traffic Calming Program mandated by the County Council in July, 1997. During the evaluation process, consideration should be given to establishing "primary emergency response routes" for fire-rescue apparatus for which traffic calming strategies would be limited to those which do not impede emergency apparatus[23]. An approach of this nature would ensure that response routes used extensively by fire-rescue vehicles on a daily basis be kept free of emergency vehicle-impeding speed humps and traffic circles, while continuing to allow the presence of humps and circles on roadways lacking the "primary emergency response route" designation. This effort should be led by DPWT and include parties having an interest in the issue.

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[22] A similar comparison to Austin cannot be made because Austin did not have traffic circles in 1996 when they conducted their tests.

[23] A similar approach is being taken in both Portland, Oregon and Austin, Texas.

APPENDIX A

ROADWAY CRITERIA FOR TESTS

Speed Hump Tests

1. Roadway with 2-4 speed humps all within a distance not greater than 0.4 mile
2. Flat or nearly flat roadway
3. Roadway with low traffic volume, in order to minimize disruption during tests
4. Dry pavement throughout all tests
5. Adequate road configuration[24] prior to Starting Point B to allow vehicle acceleration to at least 25 mph
6. Adequate road configuration beyond final speed hump to allow vehicle acceleration to at least 25 mph
7. Roadway with limited number of residences, preferably set back from street

Traffic Circle Tests

1. Roadway with at least 1 traffic circle
2. Flat or nearly flat roadway
3. Roadway with low traffic volume, in order to minimize disruption during tests
4. Dry pavement throughout all tests
5. Adequate road configuration prior to Starting Point B to allow vehicle acceleration to at least 25 mph
6. Adequate road configuration beyond final traffic circle to allow vehicle acceleration to at least 25 mph
7. Roadway with limited number of residences, preferably set back from street

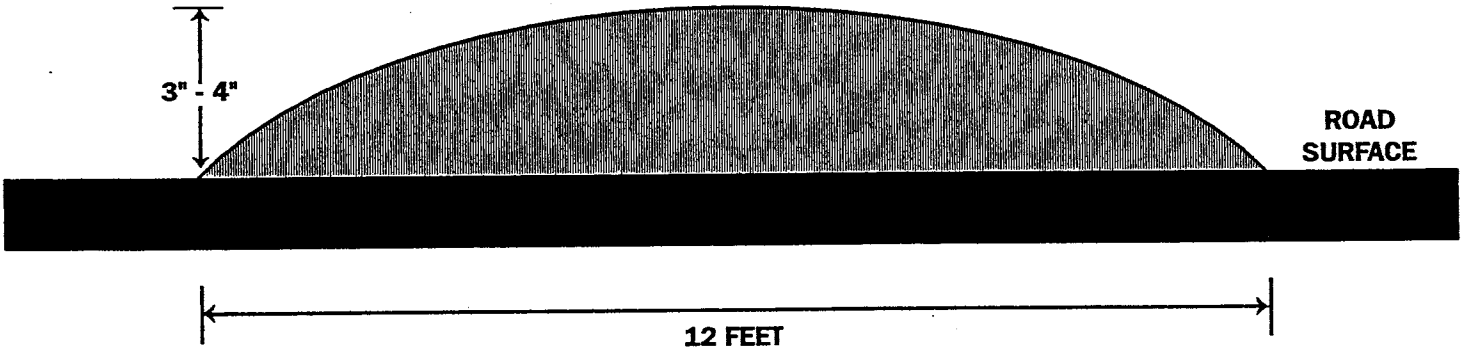
[24] Adequate roadway configuration and distance to allow for straight, unimpeded travel by test vehicles in order that they may accelerate to a speed of at least 25 mph.

APPENDIX B

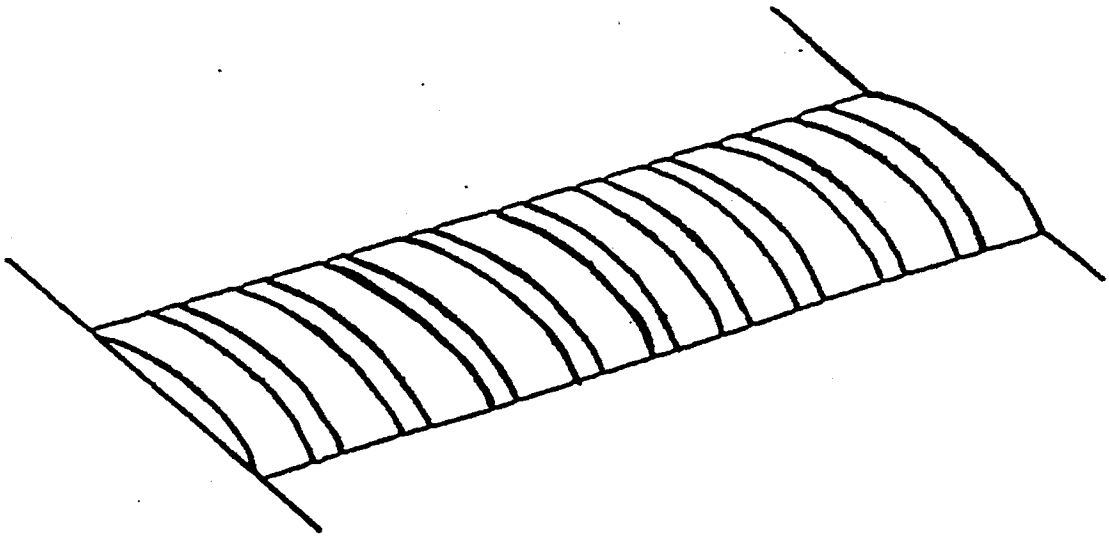
WATTS SPEED HUMP

CROSS-SECTION

(NOT DRAWN TO SCALE)



TOP VIEW



APPENDIX C
MONTGOMERY COUNTY FIRE-RESCUE/DPW&T
SPEED HUMP AND TRAFFIC CIRCLE TESTS

Test #	Unit	Driver	Desirable Speed	Type TCD/Test
1P*	T**	A, B or C	25 mph	Multiple Watts Humps at discretionary speed
2A	E	A	25 mph	Multiple Watts Humps at discretionary speed
2B	E	B	25 mph	Multiple Watts Humps at discretionary speed
2C	E	C	25 mph	Multiple Watts Humps at discretionary speed
3A	T	A	25 mph	Multiple Watts Humps at discretionary speed
3B	T	B	25 mph	Multiple Watts Humps at discretionary speed
3C	T	C	25 mph	Multiple Watts Humps at discretionary speed
4A	AT	A	25 mph	Multiple Watts Humps at discretionary speed
4B	AT	B	25 mph	Multiple Watts Humps at discretionary speed
4C	AT	C	25 mph	Multiple Watts Humps at discretionary speed
5A	A	A	25 mph	Multiple Watts Humps at discretionary speed
5B	A	B	25 mph	Multiple Watts Humps at discretionary speed
5C	A	C	25 mph	Multiple Watts Humps at discretionary speed
6P*	T**	A, B or C	35 mph	Traffic Circle at discretionary speed
7A	E	A	35 mph	Traffic Circle at discretionary speed
7B	E	B	35 mph	Traffic Circle at discretionary speed
7C	E	C	35 mph	Traffic Circle at discretionary speed
8A	T	A	35 mph	Traffic Circle at discretionary speed
8B	T	B	35 mph	Traffic Circle at discretionary speed
8C	T	C	35 mph	Traffic Circle at discretionary speed
9A	AT	A	35 mph	Traffic Circle at discretionary speed
9B	AT	B	35 mph	Traffic Circle at discretionary speed
9C	AT	C	35 mph	Traffic Circle at discretionary speed
10A	A	A	35 mph	Traffic Circle at discretionary speed
10B	A	B	35 mph	Traffic Circle at discretionary speed
10C	A	C	35 mph	Traffic Circle at discretionary speed]

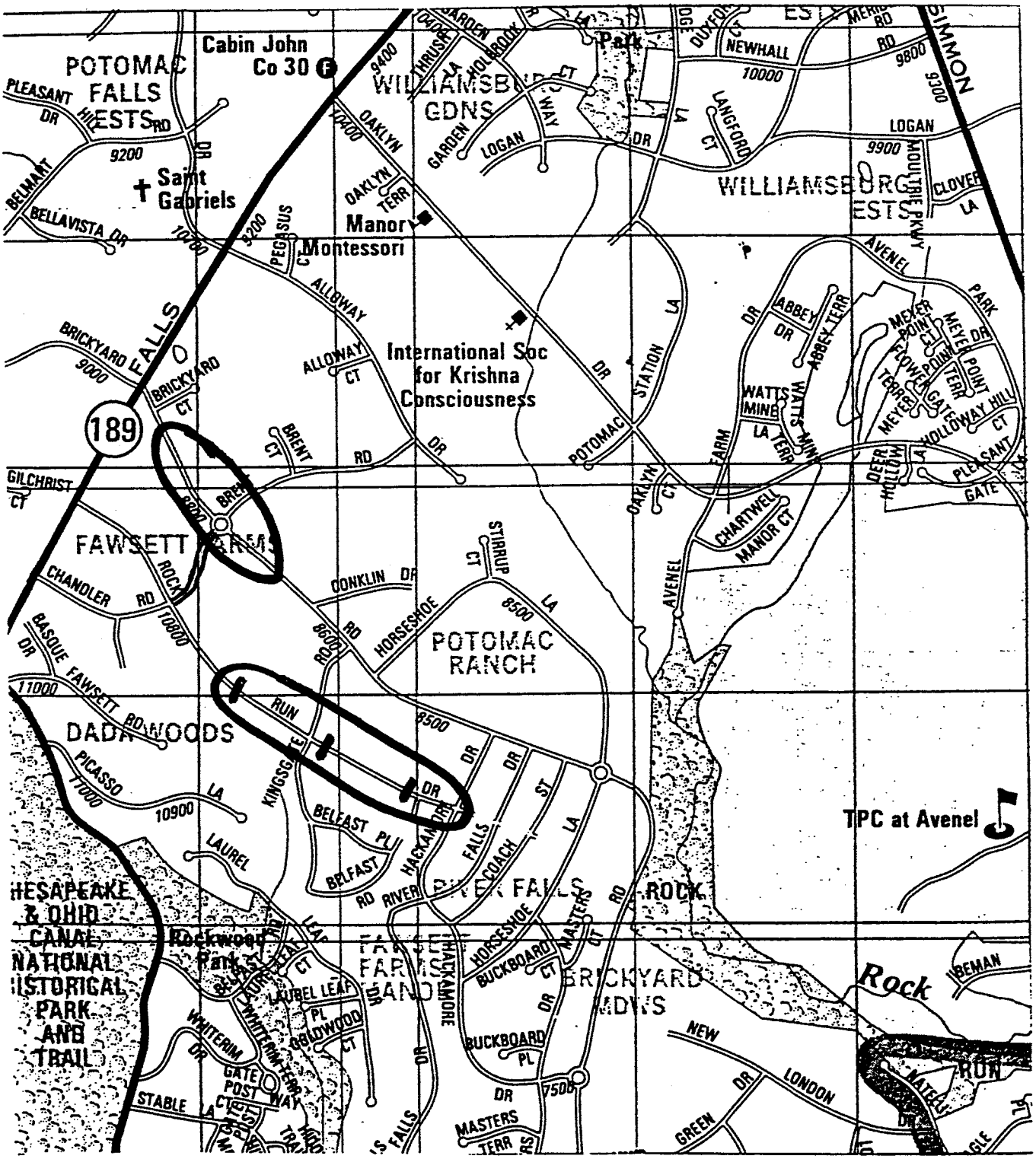
E = Engine A = Ambulance T = Truck-Tiller AT = Aerial Tower

* P - Pre-test run as described in text

** Test vehicle with slowest acceleration rate (i.e., Truck 10 - Tiller-style ladder truck)

APPENDIX D

TEST COURSE LOCATIONS



APPENDIX E

NOTIFICATION OF RESIDENTS OF UPCOMING TESTS

MONTGOMERY COUNTY FIRE AND RESCUE COMMISSION

Douglas M. Duncan
County Executive

George Giebel
Chairman

April 11, 1997

Dear Resident:

The Montgomery County Fire and Rescue Commission (FRC) and Department of Public Works and Transportation (DPW&T) will soon be conducting a series of low-speed, non-emergency tests involving fire-rescue vehicles traversing traffic calming devices (e.g., speed humps, traffic circles) in your neighborhood. In order to minimize disruption to you and your neighbors, the tests will be conducted on a weekday between the hours of 9:00 a.m. and 3:00 p.m. The tests will be conducted promptly, and strict attention to safety will be maintained.

The tests are planned for April 22, 1997. In the event of adverse weather on that date, April 23 and 24 would be the alternate dates. Tests will be conducted along Rock Run Drive and along Brickyard Road in the vicinity of Brent Road. The tests should have little or no effect on residents, however, motorists may experience minor delays during each test run. Police officers will provide traffic/access control during the tests but will allow traffic to flow between test runs, each of which should take approximately 2 minutes.

The purpose of the tests is to determine the amount of delay experienced by various-sized fire-rescue vehicles in traversing typical roadways containing traffic calming devices. Your neighborhood has been selected for these tests due to Rock Run Drive and Brickyard Road both meeting our test criteria. Test findings will prove useful to County residents and officials who must weigh the positive and negative aspects of traffic calming devices when contemplating their future usage and specific placement. Rest assured that the tests are not intended to result in the removal or modification of existing traffic calming devices in your neighborhood.

We thank you for your consideration and patience as we conduct these important tests. Once again, the tests will be conducted in a prompt and safe manner, and we anticipate minimal disruption to you and your neighbors. If you have any questions, please contact Scott Gutschick, Administrative Specialist, FRC, on 217-3696, or David Loughery, Unit Leader, Neighborhood Traffic Planning, DPW&T, on 217-2210.

Sincerely,

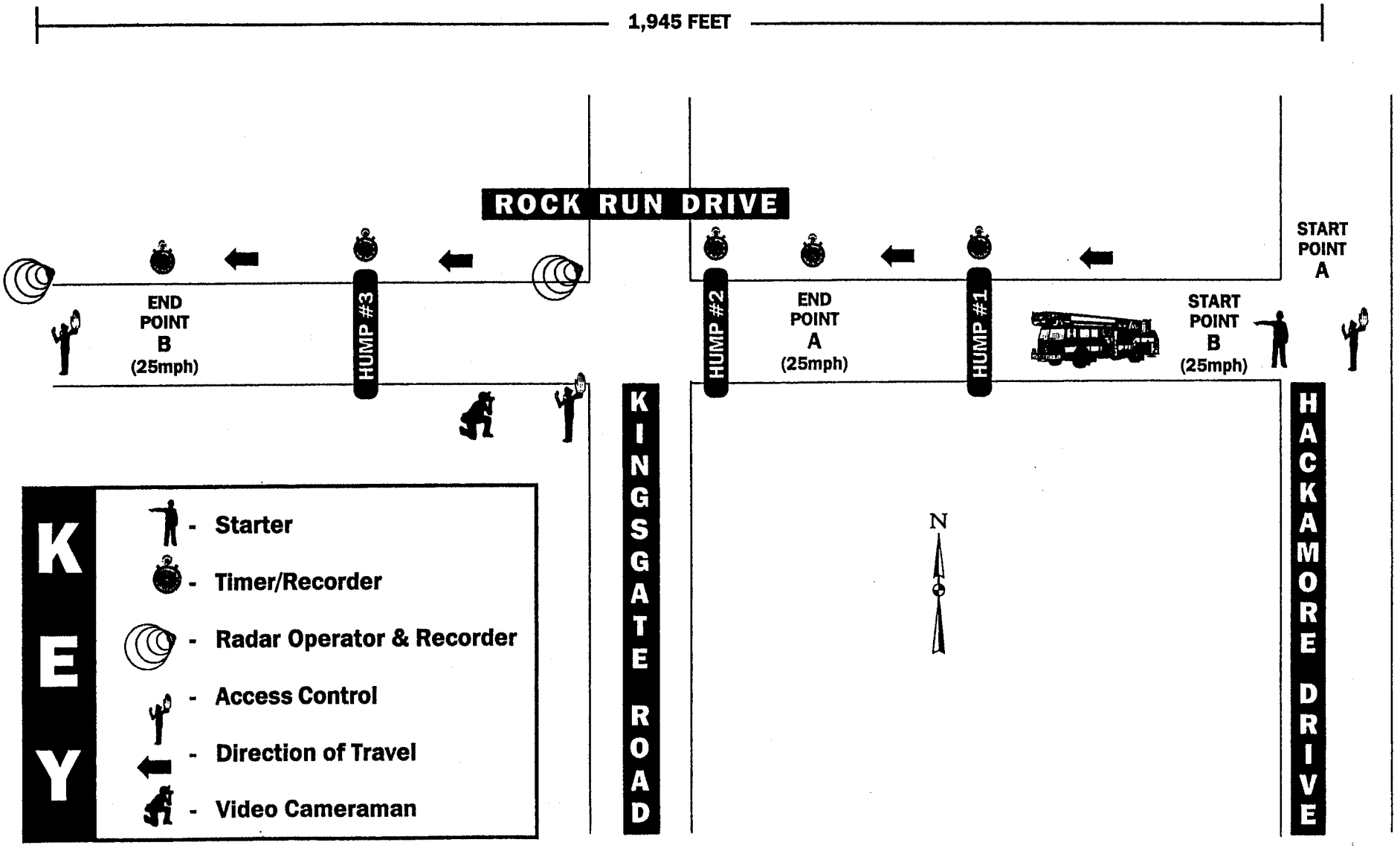
George Giebel, Chairman
Fire and Rescue Commission

For Graham J. Norton, Director
Department of Public Works &Transportation

101 Monroe Street, 12th Floor • Rockville, Maryland 20850-2589 • 301/217-2461. TDD 301/217-4625. FAX 301/217-2526

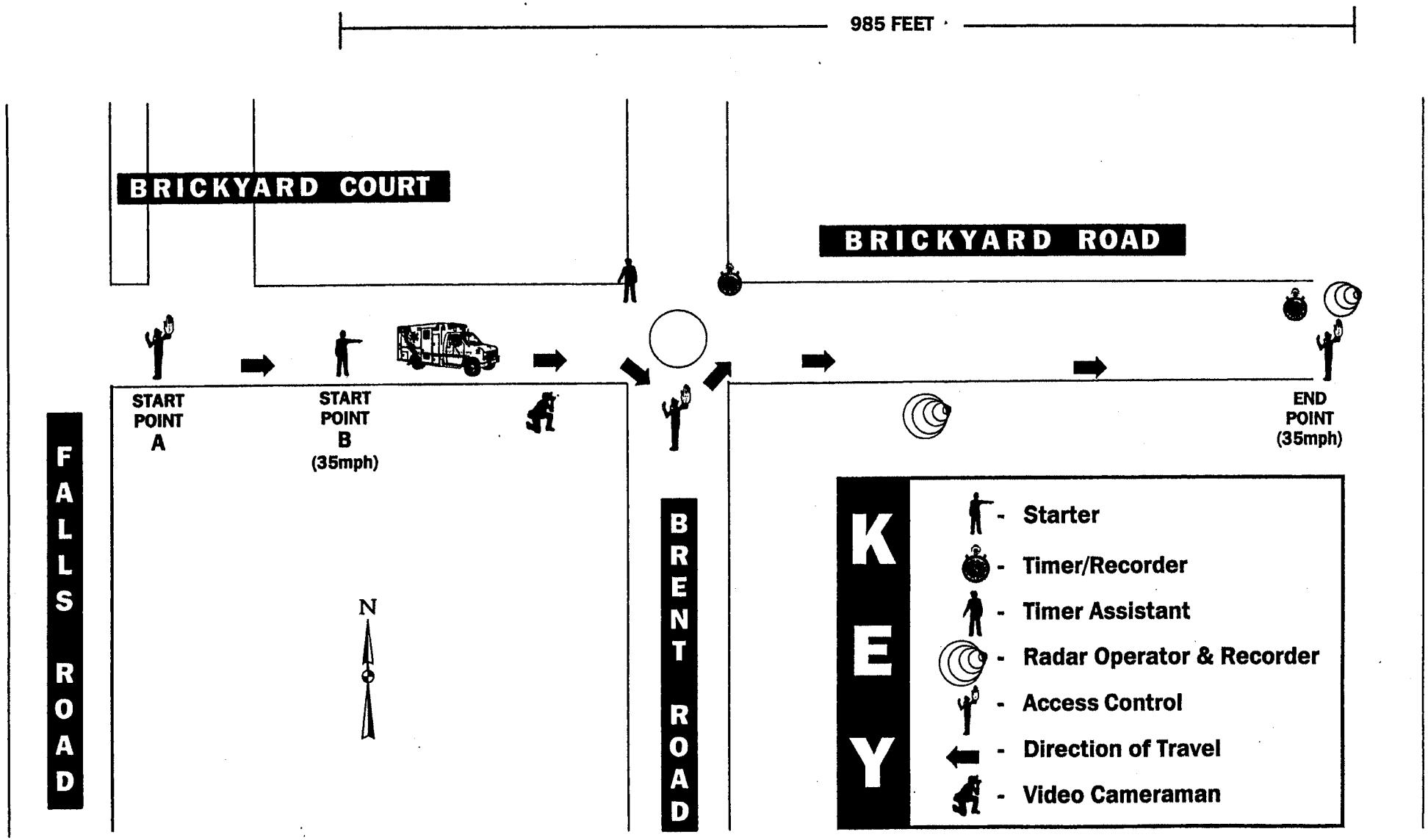
APPENDIX F-1

SPEED HUMP TEST COURSE



APPENDIX F-2

TRAFFIC CIRCLE TEST COURSE



APPENDIX G

RESOURCE REQUIREMENTS

Personnel	Responsible Agency
3 Qualified fire-rescue apparatus drivers per vehicle type	DFRS
1 Starter/Test Coordinator positioned at Starting Point	FRC
1 Timer/Recorder per hump/circle (1-3 total)	DFRS
1 Timer/Recorder positioned at End Point	DFRS
2 RADAR Operators	DPWT
2 RADAR Data Recorders	DFRS
1 Traffic Controller per access control point (2-4 total)	MCPD
1 Video Camera Operator	DFRS
Apparatus	
1 Engine	CJPVFD
1 100-ft Ladder Truck, tiller-style	CJPVFD
1 100-ft Aerial Tower	BFD
1 Ambulance, Freightliner-type	HVFD
Equipment	
1 Roll-a-Tape measuring device	DPWT
8 Digital stop watches	DFRS/MCPD/DPWT
2 RADAR devices	DPWT
1 Video camera	DFRS
8 Clipboards	FRC/DFRS/DPWT
Test data recording sheets	FRC
8 Portable radios	DFRS
Traffic control cones	DPWT

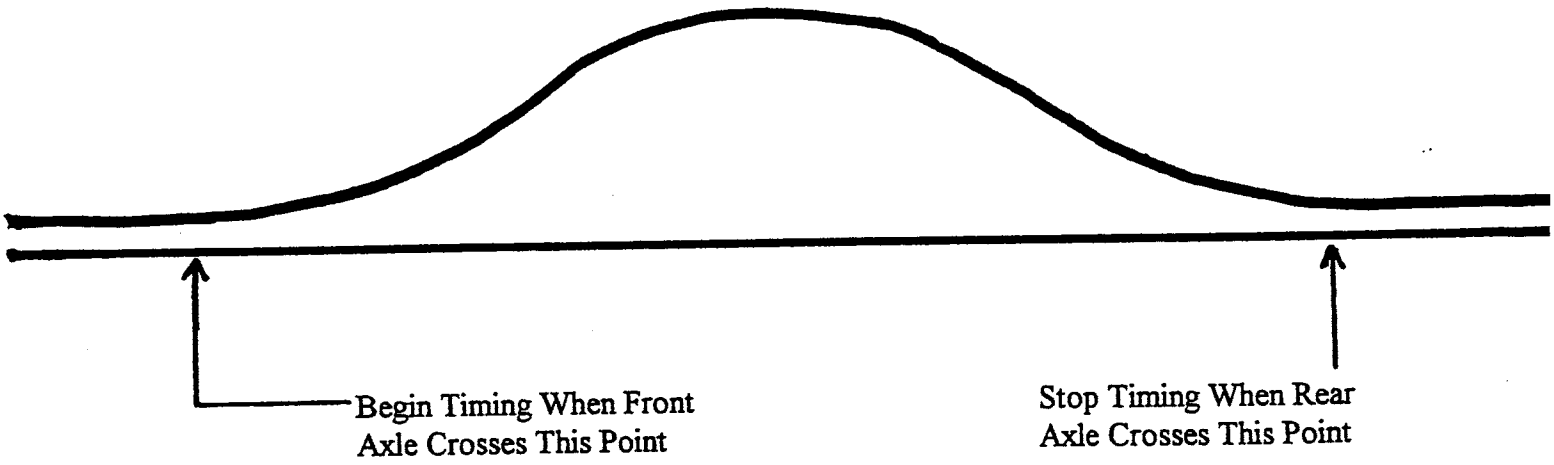
FRC = Fire and Rescue Commission
DFRS = Department of Fire and Rescue Services
DPWT = Department of Public Works and Transportation
MCPD = Montgomery County Police Department
CJPVFD = Cabin John Park Volunteer Fire Department
BFD = Bethesda Fire Department
HVFD = Hillandale Volunteer Fire Department

APPENDIX H

SAMPLE FIELD TEST RECORDING SHEETS

DATA SHEET FOR SPEED HUMP #1 TIMER/RECORDER

TEST #	UNIT #	TIME TO TRAVERSE HUMP #1 (SECONDS)
2A		
2B		
2C		
3A		
3B		
3C		
4A		
4B		
4C		
5A		
5B		
5C		



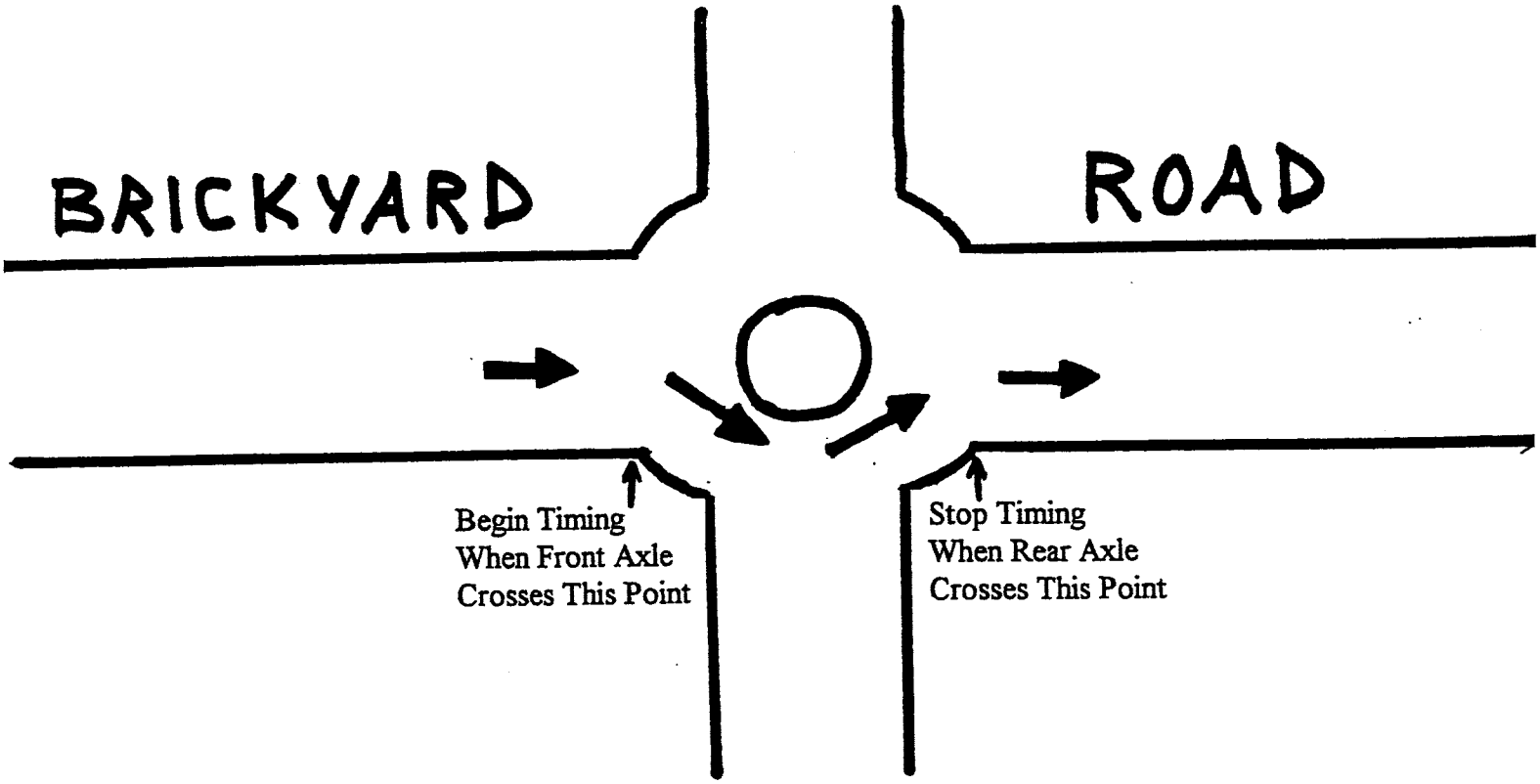
DATA SHEET FOR ENDING POINT B TIMER
(MULTIPLE SPEED HUMP TESTS)

Test #	Unit #	Time to Traverse* Multiple -Hump Course (Seconds)
2A		
2B		
2C		
3A		
3B		
3C		
4A		
4B		
4C		
5A		
5B		
5C		

* Begin timing upon Starter's signal; end timing when front axle crosses End Point B

DATA SHEET FOR TIMER
FOR TRAFFIC CIRCLE TESTS

TEST #	UNIT #	TIME TO TRAVERSE CIRCLE (SECONDS)
7A		
7B		
7C		
8A		
8B		
8C		
9A		
9B		
9C		
10A		
10B		
10C		



DATA SHEET FOR ENDING POINT TIMER
(TRAFFIC CIRCLE TESTS)

Test #	Unit #	Time to Traverse* Traffic Circle Course (Seconds)
7A		
7B		
7C		
8A		
8B		
8C		
9A		
9B		
9C		
10A		
10B		
10C		

* Begin timing upon Starter's signal; end timing when front axle crosses End Point

RADAR DATA SHEET FOR TRAFFIC CIRCLE TESTS

Test #	Unit #	Speed @ Start Point B	Lowest Speed @ Circle	Speed @ End Point
6P				
7A				
7B				
7C				
8A				
8B				
8C				
9A				
9B				
9C				
10A				
10B				
10C				

APPENDIX I

SPEED HUMP AND TRAFFIC CIRCLE TEST RESULTS

APPENDIX I-1

TEST RESULTS OF FIRE-RESCUE UNITS TRAVERSING MULTIPLE SPEED HUMP COURSE (1945 FT. AT 25 MPH)

Test #	Unit #	Time To Traverse Hump # 1 (Secs.)	Delay * at Hump # 1 (SECS.)	Lowest Speed Hump # 1 (MPH)	Time to Traverse Hump # 2 (Secs.)	Delay * at Hump # 2 (Secs.)	Lowest Speed at Hump # 2 (MPH)	Time to Traverse Hump # 3 (Secs.)	Delay * at Hump # 3 (Secs.)	Lowest Speed at Hump # 3 (MPH)	Time to Traverse Course (Secs.)	Travel Time Delay ** (Secs.)	Avg. Travel Time Delay Per Hump (Secs.)	Avg. Lowest Speed Per Hump (MPH)
2A	E301	1.9	1.6	9.0	2.2	1.9	6.0	2.0	1.7	10.0	67.0	14.0		
2B	E301	2.2	1.9	7.0	2.4	2.1	8.0	2.5	2.2	10.0	67.0	14.0		
2C	E301	1.9	1.6	9.0	1.6	1.3	10.0	1.5	1.2	13.0	63.0	10.0		
AVG.	E301	2.0	1.7	8.3	2.0	1.7	8.0	2.0	1.7	11.0	65.7	12.7	4.2	9.1
3A	T10	4.2	3.9	6.0	5.3	5.0	5.0	5.5	5.2	10.0	74.0	21.0		
3B	T10	4.2	3.9	7.0	3.8	3.5	7.0	4.3	4.0	11.0	70.0	17.0		
3C	T10	5.4	5.1	5.0	6.8	6.5	4.0	6.2	5.9	0.0	81.0	28.0		
AVG.	T10	4.6	4.3	6.0	5.3	5.0	5.3	5.4	5.1	7.0	75.0	22.0	7.3	6.1
4A	AT6	3.1	2.8	6.0	3.1	2.8	6.0	2.9	2.6	10.0	64.0	11.0		
4B	AT6	1.7	1.4	13.0	2.2	1.9	10.0	2.2	1.9	11.0	60.0	7.0		
4C	AT6	1.9	1.6	12.0	1.0	0.7	16.0	2.2	1.9	13.0	60.0	7.0		
AVG.	AT6	2.2	1.9	10.3	2.1	1.8	10.7	2.4	2.1	11.3	61.3	8.3	2.8	10.8
5A	A248	2.0	1.7	8.0	2.4	2.1	8.0	1.5	1.2	10.0	66.0	13.0		
5B	A248	1.8	1.5	9.0	1.7	1.4	9.0	1.8	1.5	10.0	64.0	11.0		
5C	A248	2.1	1.8	7.0	2.3	2.0	7.0	1.8	1.3	10.0	63.0	10.0		
AVG.	A248	2.0	1.7	8.0	2.1	1.8	8.0	1.7	1.4	10.0	64.3	11.3	3.8	8.7
MULTIPLE.WK4														

* Delay at Hump = [Time to traverse 12 Ft. Hump] - [Calculated time (0.3 secs.) over 12 Ft. of Roadway without Humps]

** Total Delay attributed to Humps = [Time to traverse 1945 Ft. Test Course] - [Calculated time (53.0 secs.) to travel same distance without Humps]

E = Engine
T = (Ladder) Truck
AT = Aerial Tower
A = Ambulance

APPENDIX I-2

RESPONSE TIME IMPACT OF SPEED HUMPS ON FIRE-RESCUE APPARATUS

	Truck 10 *at 25 mph*	Aerial Tower 6 *at 25mph*	Engine 301 *at 25 mph*	Ambulance 248 *at 25 mph*
Calculated Time to Traverse 1945 ft. Course (secs.)	53.0	53.0	53.0	53.0
(1) Measured Time to Traverse 1945 ft. Course (secs.)	75.0	61.3	65.7	64.3
Delay Attributed to 3-Hump Course (secs.)	22.0	8.3	12.7	11.3
Average Delay Per Hump (secs.)	7.3	2.8	4.2	3.8
(2) Equivalent Distance from Station Per Hump (miles)	0.05	0.02	0.03	0.03
(3) 5-min. Response Distance (miles)	1.5	1.5	1.5	1.5
(4) Distance-Response Time Impact of Humps	1/4 mile per 4.9 Humps	1/4 mile per 12.5 Humps	1/4 mile per 8.6 Humps	1/4 mile per 9.6 Humps

(1) Figures are actual times for tests run at 25 mph .

(2) Increase in distance between station and incident location along hump-free route that is equivalent to the delay impact of a single hump along a hump-impeded route.

(3) 5-min. response goal assumes 1.5 minutes for dispatch, turnout, and acceleration up to "cruising speed"; 3.5 minutes for travel time.

(4) Number of humps that would necessitate the shortening of the distance between the station and incident location by 1/4 mile in order to maintain a 5 min. response time (see Note 3) at the cruising speed of 25 mph; or number of humps that would, effectively, increase the distance between the station and incident location by 1/4 mile compared to a response route without humps, assuming a travel speed of 25 mph.

TEST RESULTS OF FIRE-RESCUE UNITS TRAVERSING TRAFFIC CIRCLE COURSE (985 FT. AT 35 MPH)

APPENDIX I-3

Test #	Unit #	Time to Traverse Circle (Secs.)	Lowest Speed at Circle (MPH)	Delay At Circle * (Secs.)	Time to Traverse Course (Secs.)	Travel Time Delay ** (Secs.)
7A	E301	4.0	11.0	2.9	25.1	5.9
7B	E301	4.0	13.0	2.9	24.5	5.3
7C	E301	2.1	18.0	1.0	23.0	3.8
AVG.	**E301**	**3.4**	**14.0**	**2.3**	**24.2**	**5.0**
8A	T10	5.5	9.0	4.4	28.2	9.0
8B	T10	6.2	8.0	5.1	26.5	7.3
8C	T10	4.3	14.0	3.2	23.8	4.6
AVG.	**T10**	**5.3**	**10.3**	**4.2**	**26.2**	**7.0**
9A	AT6	4.6	10.0	3.5	25.7	6.5
9B	AT6	4.1	11.0	3.0	22.7	3.5
9C	AT6	5.5	10.0	4.4	25.3	6.1
AVG.	**AT6**	**4.7**	**10.3**	**3.6**	**24.6**	**5.4**
10A	A248	2.5	13.0	1.4	23.5	4.3
10B	A248	2.3	13.0	1.2	22.4	3.2
10C	A248	2.2	16.0	1.1	21.4	2.2
AVG.	**A248**	**2.3**	**14.0**	**1.2**	**22.4**	**3.2**
TRAFICIR.WK4						

* Delay at Circle = [Time to traverse half circle] - [Calculated time (1.1 secs.) to travel same distance (58 ft.) on straight roadway)

** Total Delay attributed to Circle = [Time to traverse 985 ft. test course] - [Calculated time (19.2 secs.) to travel same distance without circle]

E = Engine
T = (Ladder) Truck
AT = Aerial Tower
A = Ambulance

APPENDIX I-4

SPEED HUMP TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 2A Unit # E301 Unit Weight: 37,900 lbs. Unit Dimensions: 30'5" (L) 8'0" (W) 9'3" (H)

Hump Type: 12 ft Watts Test Site: Rock Run Drive (10600 to 10800 block), Potomac, Maryland

Date: 4/30/97 Time Period: 10:30 a.m.-12:00 p.m. Weather/Road Conditions: Sunny, 65-70^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to 1st Hump: 245 feet

1st Hump to End Point A: 322 feet

End Point A to 2nd Hump: 303 feet

2nd Hump to 3rd Hump: 748 feet

3rd Hump to End Point B: 327 feet

Single-Hump Course Length: 567 feet (from Starting Point B to Ending Point A)

Multiple-Hump Course Length: 1945 feet (from Starting Point B to Ending Point B)

TEST TIMING/SPEED DATA

Speed at Starting Point B: 27 mph

Lowest Speed Traversing Hump #1: 9 mph

Time to Traverse Hump #1: 1.9 seconds

Lowest Speed Traversing Hump #2: 6 mph

Time to Traverse Hump #2: 2.2 seconds

Lowest Speed Traversing Hump #3: 10 mph

Time to Traverse Hump #3: 2.0 seconds

Speed at Ending Point A: 27 mph

Time from Starting Pt. B to Ending Pt. A: 20.1 seconds

Speed at Ending Point B: 26 mph

Time from Starting Pt. B to Ending Pt. B: 67.0 seconds

SPEED HUMP TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 2B Unit # E301 Unit Weight: 37,900 lbs. Unit Dimensions: 30'5" (L) 8'0" (W) 9'3" (H)

Hump Type: 12 ft Watts Test Site: Rock Run Drive (10600 to 10800 block), Potomac, Maryland

Date: 4/30/97 Time Period: 10:30 a.m.-12:00 p.m. Weather/Road Conditions: Sunny, 65-70^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to 1st Hump: 245 feet

1st Hump to End Point A: 322 feet

End Point A to 2nd Hump: 303 feet

2nd Hump to 3rd Hump: 748 feet

3rd Hump to End Point B: 327 feet

Single-Hump Course Length: 567 feet (from Starting Point B to Ending Point A)

Multiple-Hump Course Length: 1945 feet (from Starting Point B to Ending Point B)

TEST TIMING/SPEED DATA

Speed at Starting Point B: 27 mph

Lowest Speed Traversing Hump #1: 7 mph

Time to Traverse Hump #1: 2.2 seconds

Lowest Speed Traversing Hump #2: 8 mph

Time to Traverse Hump #2: 2.4 seconds

Lowest Speed Traversing Hump #3: 10 mph

Time to Traverse Hump #3: 2.5 seconds

Speed at Ending Point A: 28 mph

Time from Starting Pt. B to Ending Pt. A: 20.1 seconds

Speed at Ending Point B: 26 mph

Time from Starting Pt. B to Ending Pt. B: 67.0 seconds

SPEED HUMP TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 2C Unit # E301 Unit Weight: 37,900 lbs. Unit Dimensions: 30'5" (L) 8'0" (W) 9'3" (H)

Hump Type: 12 ft Watts Test Site: Rock Run Drive (10600 to 10800 block), Potomac, Maryland

Date: 4/30/97 Time Period: 10:30 a.m.-12:00 p.m. Weather/Road Conditions: Sunny, 65-70^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to 1st Hump: 245 feet

1st Hump to End Point A: 322 feet

End Point A to 2nd Hump: 303 feet

2nd Hump to 3rd Hump: 748 feet

3rd Hump to End Point B: 327 feet

Single-Hump Course Length: 567 feet (from Starting Point B to Ending Point A)

Multiple-Hump Course Length: 1945 feet (from Starting Point B to Ending Point B)

TEST TIMING/SPEED DATA

Speed at Starting Point B: 27 mph

Lowest Speed Traversing Hump #1: 9 mph

Time to Traverse Hump #1: 2.0 seconds

Lowest Speed Traversing Hump #2: 10 mph

Time to Traverse Hump #2: 1.6 seconds

Lowest Speed Traversing Hump #3: 13 mph

Time to Traverse Hump #3: 1.5 seconds

Speed at Ending Point A: 28 mph

Time from Starting Pt. B to Ending Pt. A: 19.8 seconds

Speed at Ending Point B: 26 mph

Time from Starting Pt. B to Ending Pt. B: 63.0 seconds

SPEED HUMP TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 3A Unit # T10 Unit Weight: 54,200 lbs. Unit Dimensions: 55'10" (L) 9'10" (W) 11'4" (H)

Hump Type: 12 ft Watts Test Site: Rock Run Drive (10600 to 10800 block), Potomac, Maryland

Date: 4/30/97 Time Period: 10:30 a.m.-12:00 p.m. Weather/Road Conditions: Sunny, 65-70^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to 1st Hump: 245 feet

1st Hump to End Point A: 322 feet

End Point A to 2nd Hump: 303 feet

2nd Hump to 3rd Hump: 748 feet

3rd Hump to End Point B: 327 feet

Single-Hump Course Length: 567 feet (from Starting Point B to Ending Point A)

Multiple-Hump Course Length: 1945 feet (from Starting Point B to Ending Point B)

TEST TIMING/SPEED DATA

Speed at Starting Point B: 26 mph

Lowest Speed Traversing Hump #1: 6 mph

Time to Traverse Hump #1: 4.2 seconds

Lowest Speed Traversing Hump #2: 5 mph

Time to Traverse Hump #2: 5.3 seconds

Lowest Speed Traversing Hump #3: 10 mph

Time to Traverse Hump #3: 5.5 seconds

Speed at Ending Point A: 27 mph

Time from Starting Pt. B to Ending Pt. A: 21.2 seconds

Speed at Ending Point B: 25 mph

Time from Starting Pt. B to Ending Pt. B: 74.0 seconds

SPEED HUMP TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 3B Unit # T10 Unit Weight: 54,200 lbs. Unit Dimensions: 55'10" (L) 9'10" (W) 11'4" (H)

Hump Type: 12 ft Watts Test Site: Rock Run Drive (10600 to 10800 block), Potomac, Maryland

Date: 4/30/97 Time Period: 10:30 a.m.-12:00 p.m. Weather/Road Conditions: Sunny, 65-70^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to 1st Hump: 245 feet

1st Hump to End Point A: 322 feet

End Point A to 2nd Hump: 303 feet

2nd Hump to 3rd Hump: 748 feet

3rd Hump to End Point B: 327 feet

Single-Hump Course Length: 567 feet (from Starting Point B to Ending Point A)

Multiple-Hump Course Length: 1945 feet (from Starting Point B to Ending Point B)

TEST TIMING/SPEED DATA

Speed at Starting Point B: 26 mph

Lowest Speed Traversing Hump #1: 7 mph

Time to Traverse Hump #1: 4.2 seconds

Lowest Speed Traversing Hump #2: 7 mph

Time to Traverse Hump #2: 3.8 seconds

Lowest Speed Traversing Hump #3: 11 mph

Time to Traverse Hump #3: 4.3 seconds

Speed at Ending Point A: 27 mph

Time from Starting Pt. B to Ending Pt. A: 21.0 seconds

Speed at Ending Point B: 24 mph

Time from Starting Pt. B to Ending Pt. B: 70.0 seconds

SPEED HUMP TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 3C Unit # T10 Unit Weight: 54,200 lbs. Unit Dimensions: 55'10" (L) 9'10" (W) 11'4" (H)

Hump Type: 12 ft Watts Test Site: Rock Run Drive (10600 to 10800 block), Potomac, Maryland

Date: 4/30/97 Time Period: 10:30 a.m.-12:00 p.m. Weather/Road Conditions: Sunny, 65-70^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to 1st Hump: 245 feet

1st Hump to End Point A: 322 feet

End Point A to 2nd Hump: 303 feet

2nd Hump to 3rd Hump: 748 feet

3rd Hump to End Point B: 327 feet

Single-Hump Course Length: 567 feet (from Starting Point B to Ending Point A)

Multiple-Hump Course Length: 1945 feet (from Starting Point B to Ending Point B)

TEST TIMING/SPEED DATA

Speed at Starting Point B: 26 mph

Lowest Speed Traversing Hump #1: 5 mph

Time to Traverse Hump #1: 5.4 seconds

Lowest Speed Traversing Hump #2: 4 mph

Time to Traverse Hump #2: 6.8 seconds

Lowest Speed Traversing Hump #3: 0 mph

Time to Traverse Hump #3: 6.2 seconds

Speed at Ending Point A: 26 mph

Time from Starting Pt. B to Ending Pt. A: 23.3 seconds

Speed at Ending Point B: 25 mph

Time from Starting Pt. B to Ending Pt. B: 81.0 seconds

SPEED HUMP TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 4A Unit # AT6 Unit Weight: 50,750 lbs. Unit Dimensions: 46'3" (L) 9'3" (W) 10'3" (H)

Hump Type: 12 ft Watts Test Site: Rock Run Drive (10600 to 10800 block), Potomac, Maryland

Date: 4/30/97 Time Period: 10:30 a.m.-12:00 p.m. Weather/Road Conditions: Sunny, 65-70^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to 1st Hump: 245 feet

1st Hump to End Point A: 322 feet

End Point A to 2nd Hump: 303 feet

2nd Hump to 3rd Hump: 748 feet

3rd Hump to End Point B: 327 feet

Single-Hump Course Length: 567 feet (from Starting Point B to Ending Point A)

Multiple-Hump Course Length: 1945 feet (from Starting Point B to Ending Point B)

TEST TIMING/SPEED DATA

Speed at Starting Point B: 26 mph

Lowest Speed Traversing Hump #1: 6 mph

Time to Traverse Hump #1: 3.1 seconds

Lowest Speed Traversing Hump #2: 6 mph

Time to Traverse Hump #2: 3.1 seconds

Lowest Speed Traversing Hump #3: 10 mph

Time to Traverse Hump #3: 2.9 seconds

Speed at Ending Point A: 27 mph

Time from Starting Pt. B to Ending Pt. A: 20.7 seconds

Speed at Ending Point B: 25 mph

Time from Starting Pt. B to Ending Pt. B: 64.0 seconds

SPEED HUMP TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 4B Unit # AT6 Unit Weight: 50,750 lbs. Unit Dimensions: 46'3" (L) 9'3" (W) 10'3" (H)

Hump Type: 12 ft Watts Test Site: Rock Run Drive (10600 to 10800 block), Potomac, Maryland

Date: 4/30/97 Time Period: 10:30 a.m.-12:00 p.m. Weather/Road Conditions: Sunny, 65-70^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to 1st Hump: 245 feet

1st Hump to End Point A: 322 feet

End Point A to 2nd Hump: 303 feet

2nd Hump to 3rd Hump: 748 feet

3rd Hump to End Point B: 327 feet

Single-Hump Course Length: 567 feet (from Starting Point B to Ending Point A)

Multiple-Hump Course Length: 1945 feet (from Starting Point B to Ending Point B)

TEST TIMING/SPEED DATA

Speed at Starting Point B: 27 mph

Lowest Speed Traversing Hump #1: 13 mph

Time to Traverse Hump #1: 1.7 seconds

Lowest Speed Traversing Hump #2: 10 mph

Time to Traverse Hump #2: 2.2 seconds

Lowest Speed Traversing Hump #3: 11 mph

Time to Traverse Hump #3: 2.2 seconds

Speed at Ending Point A: 29 mph

Time from Starting Pt. B to Ending Pt. A: 17.3 seconds

Speed at Ending Point B: 27 mph

Time from Starting Pt. B to Ending Pt. B: 60.0 seconds

SPEED HUMP TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 4C Unit # AT6 Unit Weight: 50,750 lbs. Unit Dimensions: 46'3" (L) 9'3" (W) 10'3" (H)

Hump Type: 12 ft Watts Test Site: Rock Run Drive (10600 to 10800 block), Potomac, Maryland

Date: 4/30/97 Time Period: 10:30 a.m.-12:00 p.m. Weather/Road Conditions: Sunny, 65-70^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to 1st Hump: 245 feet

1st Hump to End Point A: 322 feet

End Point A to 2nd Hump: 303 feet

2nd Hump to 3rd Hump: 748 feet

3rd Hump to End Point B: 327 feet

Single-Hump Course Length: 567 feet (from Starting Point B to Ending Point A)

Multiple-Hump Course Length: 1945 feet (from Starting Point B to Ending Point B)

TEST TIMING/SPEED DATA

Speed at Starting Point B: 29 mph

Lowest Speed Traversing Hump #1: 12 mph

Time to Traverse Hump #1: 1.9 seconds

Lowest Speed Traversing Hump #2: 16 mph

Time to Traverse Hump #2: 1.0 seconds

Lowest Speed Traversing Hump #3: 13 mph

Time to Traverse Hump #3: 2.2 seconds

Speed at Ending Point A: 31 mph

Time from Starting Pt. B to Ending Pt. A: 18.6 seconds

Speed at Ending Point B: 28 mph

Time from Starting Pt. B to Ending Pt. B: 60.0 seconds

SPEED HUMP TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 5A Unit # A248 Unit Weight: 14,850 lbs. Unit Dimensions: 25'5" (L) 9'2" (W) 9'2" (H)

Hump Type: 12 ft Watts Test Site: Rock Run Drive (10600 to 10800 block), Potomac, Maryland

Date: 4/30/97 Time Period: 10:30 a.m.-12:00 p.m. Weather/Road Conditions: Sunny, 65-70^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to 1st Hump: 245 feet

1st Hump to End Point A: 322 feet

End Point A to 2nd Hump: 303 feet

2nd Hump to 3rd Hump: 748 feet

3rd Hump to End Point B: 327 feet

Single-Hump Course Length: 567 feet (from Starting Point B to Ending Point A)

Multiple-Hump Course Length: 1945 feet (from Starting Point B to Ending Point B)

TEST TIMING/SPEED DATA

Speed at Starting Point B: 28 mph

Lowest Speed Traversing Hump #1: 8 mph

Time to Traverse Hump #1: 2.0 seconds

Lowest Speed Traversing Hump #2: 8 mph

Time to Traverse Hump #2: 2.4 seconds

Lowest Speed Traversing Final TCD: 10 mph

Time to Traverse Hump #3: 1.5 seconds

Speed at Ending Point A: 26 mph

Time from Starting Pt. B to Ending Pt. A: 19.2 seconds

Speed at Ending Point B: 23 mph

Time from Starting Pt. B to Ending Pt. B: 66.0 seconds

SPEED HUMP TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 5B Unit # A248 Unit Weight: 14,850 lbs. Unit Dimensions: 25'5" (L) 9'2" (W) 9'2" (H)

Hump Type: 12 ft Watts Test Site: Rock Run Drive (10600 to 10800 block), Potomac, Maryland

Date: 4/30/97 Time Period: 10:30 a.m.-12:00 p.m. Weather/Road Conditions: Sunny, 65-70^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to 1st Hump: 245 feet

1st Hump to End Point A: 322 feet

End Point A to 2nd Hump: 303 feet

2nd Hump to 3rd Hump: 748 feet

3rd Hump to End Point B: 327 feet

Single-Hump Course Length: 567 feet (from Starting Point B to Ending Point A)

Multiple-Hump Course Length: 1945 feet (from Starting Point B to Ending Point B)

TEST TIMING/SPEED DATA

Speed at Starting Point B: 25 mph

Lowest Speed Traversing Hump #1: 9 mph

Time to Traverse Hump #1: 1.8 seconds

Lowest Speed Traversing Hump #2: 9 mph

Time to Traverse Hump #2: 1.7 seconds

Lowest Speed Traversing Hump #3: 10 mph

Time to Traverse Hump #3: 1.8 seconds

Speed at Ending Point A: 26 mph

Time from Starting Pt. B to Ending Pt. A: 19.3 seconds

Speed at Ending Point B: 22 mph

Time from Starting Pt. B to Ending Pt. B: 64.0 seconds

SPEED HUMP TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 5C Unit # A248 Unit Weight: 14,850 lbs. Unit Dimensions: 25'5" (L) 9'2" (W) 9'2" (H)

Hump Type: 12 ft Watts Test Site: Rock Run Drive (10600 to 10800 block), Potomac, Maryland

Date: 4/30/97 Time Period: 10:30 a.m.-12:00 p.m. Weather/Road Conditions: Sunny, 65-70^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to 1st Hump: 245 feet

1st Hump to End Point A: 322 feet

End Point A to 2nd Hump: 303 feet

2nd Hump to 3rd Hump: 748 feet

3rd Hump to End Point B: 327 feet

Single-Hump Course Length: 567 feet (from Starting Point B to Ending Point A)

Multiple-Hump Course Length: 1945 feet (from Starting Point B to Ending Point B)

TEST TIMING/SPEED DATA

Speed at Starting Point B: 26 mph

Lowest Speed Traversing Hump #1: 7 mph

Time to Traverse Hump #1: 2.1 seconds

Lowest Speed Traversing Hump #2: 7 mph

Time to Traverse Hump #2: 2.3 seconds

Lowest Speed Traversing Hump #3: 10 mph

Time to Traverse Hump #3: 1.8 seconds

Speed at Ending Point A: 28 mph

Time from Starting Pt. B to Ending Pt. A: 20.0 seconds

Speed at Ending Point B: 25 mph

Time from Starting Pt. B to Ending Pt. B: 63.0 seconds

APPENDIX I-5

TRAFFIC CIRCLE TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 7A Unit # E301 Unit Weight: 37,900 lbs. Unit Dimensions: 30'5" (L) 8'0" (W) 9'3" (H)

Test Site: Brickyard Road (8700-8800 block) at Brent Road (circle), Potomac, Maryland

Date: 4/30/97 Time Period: 2:00-3:30 p.m. Weather/Road Conditions: Sunny, 70-75^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to Beginning of Circle: 523 feet

Western Edge of Circle to Eastern Edge: 58 feet

Eastern Edge of Circle to Ending Point: 404 feet

Total Test Course: 985 feet

TEST TIMING/SPEED DATA

Speed at Starting Point B: 34 mph

Lowest Speed at Traffic Circle: 11 mph

Time to Traverse Traffic Circle: 4.0 seconds

Speed at Ending Point: 35 mph

Time from Starting Pt. B to Ending Point: 25.1 seconds

TRAFFIC CIRCLE TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 7B Unit # E301 Unit Weight: 37,900 lbs. Unit Dimensions: 30'5" (L) 8'0" (W) 9'3" (H)

Test Site: Brickyard Road (8700-8800 block) at Brent Road (circle), Potomac, Maryland

Date: 4/30/97 Time Period: 2:00-3:30 p.m. Weather/Road Conditions: Sunny, 70-75^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to Beginning of Circle: 523 feet

Western Edge of Circle to Eastern Edge: 58 feet

Eastern Edge of Circle to Ending Point: 404 feet

Total Test Course: 985 feet

TEST TIMING/SPEED DATA

Speed at Starting Point B: 35 mph

Lowest Speed at Traffic Circle: 13 mph

Time to Traverse Traffic Circle: 4.0 seconds

Speed at Ending Point: 35 mph

Time from Starting Pt. B to Ending Point: 24.5 seconds

TRAFFIC CIRCLE TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 7C Unit # E301 Unit Weight: 37,900 lbs. Unit Dimensions: 30'5" (L) 8'0" (W) 9'3" (H)

Test Site: Brickyard Road (8700-8800 block) at Brent Road (circle), Potomac, Maryland

Date: 4/30/97 Time Period: 2:00-3:30 p.m. Weather/Road Conditions: Sunny, 70-75^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to Beginning of Circle: 523 feet

Western Edge of Circle to Eastern Edge: 58 feet

Eastern Edge of Circle to Ending Point: 404 feet

Total Test Course: 985 feet

TEST TIMING/SPEED DATA

Speed at Starting Point B: 37 mph

Lowest Speed at Traffic Circle: 18 mph

Time to Traverse Traffic Circle: 2.1 seconds

Speed at Ending Point: 36 mph

Time from Starting Pt. B to Ending Point: 23.0 seconds

TRAFFIC CIRCLE TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 8A Unit # T10 Unit Weight: 54,200 lbs. Unit Dimensions: 55'10" (L) 9'10" (W) 11'4" (H)

Test Site: Brickyard Road (8700-8800 block) at Brent Road (circle), Potomac, Maryland

Date: 4/30/97 Time Period: 2:00-3:30 p.m. Weather/Road Conditions: Sunny, 70-75^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to Beginning of Circle: 523 feet

Western Edge of Circle to Eastern Edge: 58 feet

Eastern Edge of Circle to Ending Point: 404 feet

Total Test Course: 985 feet

TEST TIMING/SPEED DATA

Speed at Starting Point B: 33 mph

Lowest Speed at Traffic Circle: 9 mph

Time to Traverse Traffic Circle: 5.5 seconds

Speed at Ending Point: 34 mph

Time from Starting Pt. B to Ending Point: 28.2 seconds

TRAFFIC CIRCLE TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 8B Unit # T10 Unit Weight: 54,200 lbs. Unit Dimensions: 55'10" (L) 9'10" (W) 11'4" (H)

Test Site: Brickyard Road (8700-8800 block) at Brent Road (circle), Potomac, Maryland

Date: 4/30/97 Time Period: 2:00-3:30 p.m. Weather/Road Conditions: Sunny, 70-75^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to Beginning of Circle: 523 feet

Western Edge of Circle to Eastern Edge: 58 feet

Eastern Edge of Circle to Ending Point: 404 feet

Total Test Course: 985 feet

TEST TIMING/SPEED DATA

Speed at Starting Point B: 33 mph

Lowest Speed at Traffic Circle: 8 mph Time to Traverse Traffic Circle: 6.2 seconds

Speed at Ending Point: 35 mph Time from Starting Pt. B to Ending Point: 26.5 seconds

TRAFFIC CIRCLE TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 8C Unit # T10 Unit Weight: 54,200 lbs. Unit Dimensions: 55'10" (L) 9'10" (W) 11'4" (H)

Test Site: Brickyard Road (8700-8800 block) at Brent Road (circle), Potomac, Maryland

Date: 4/30/97 Time Period: 2:00-3:30 p.m. Weather/Road Conditions: Sunny, 70-75^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to Beginning of Circle: 523 feet

Western Edge of Circle to Eastern Edge: 58 feet

Eastern Edge of Circle to Ending Point: 404 feet

Total Test Course: 985 feet

TEST TIMING/SPEED DATA

Speed at Starting Point B: 32 mph

Lowest Speed at Traffic Circle: 14 mph

Time to Traverse Traffic Circle: 4.3 seconds

Speed at Ending Point: 35 mph

Time from Starting Pt. B to Ending Point: 23.8 seconds

TRAFFIC CIRCLE TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 9A Unit # AT6 Unit Weight: 50,750 lbs. Unit Dimensions: 46'3" (L) 9'3" (W) 10'3" (H)

Test Site: Brickyard Road (8700-8800 block) at Brent Road (circle), Potomac, Maryland

Date: 4/30/97 Time Period: 2:00-3:30 p.m. Weather/Road Conditions: Sunny, 70-75^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to Beginning of Circle: 523 feet

Western Edge of Circle to Eastern Edge: 58 feet

Eastern Edge of Circle to Ending Point: 404 feet

Total Test Course: 985 feet

TEST TIMING/SPEED DATA

Speed at Starting Point B: 35 mph

Lowest Speed at Traffic Circle: 10 mph

Time to Traverse Traffic Circle: 4.6 seconds

Speed at Ending Point: 35 mph

Time from Starting Pt. B to Ending Point: 25.7 seconds

TRAFFIC CIRCLE TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 9B Unit # AT6 Unit Weight: 50,750 lbs. Unit Dimensions: 46'3" (L) 9'3" (W) 10'3" (H)

Test Site: Brickyard Road (8700-8800 block) at Brent Road (circle), Potomac, Maryland

Date: 4/30/97 Time Period: 2:00-3:30 p.m. Weather/Road Conditions: Sunny, 70-75^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to Beginning of Circle: 523 feet

Western Edge of Circle to Eastern Edge: 58 feet

Eastern Edge of Circle to Ending Point: 404 feet

Total Test Course: 985 feet

TEST TIMING/SPEED DATA

Speed at Starting Point B: 38 mph

Lowest Speed at Traffic Circle: 11 mph

Time to Traverse Traffic Circle: 4.1 seconds

Speed at Ending Point: 36 mph

Time from Starting Pt. B to Ending Point: 22.7 seconds

TRAFFIC CIRCLE TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 9C Unit # AT6 Unit Weight: 50,750 lbs. Unit Dimensions: 46'3" (L) 9'3" (W) 10'3" (H)

Test Site: Brickyard Road (8700-8800 block) at Brent Road (circle), Potomac, Maryland

Date: 4/30/97 Time Period: 2:00-3:30 p.m. Weather/Road Conditions: Sunny, 70-75^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to Beginning of Circle: 523 feet

Western Edge of Circle to Eastern Edge: 58 feet

Eastern Edge of Circle to Ending Point: 404 feet

Total Test Course: 985 feet

TEST TIMING/SPEED DATA

Speed at Starting Point B: 37 mph

Lowest Speed at Traffic Circle: 10 mph

Time to Traverse Traffic Circle: 5.5 seconds

Speed at Ending Point: 35 mph

Time from Starting Pt. B to Ending Point: 25.3 seconds

TRAFFIC CIRCLE TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 10A Unit # A248 Unit Weight: 14,850 lbs. Unit Dimensions: 25'5" (L) 9'2" (W) 9'2" (H)

Test Site: Brickyard Road (8700-8800 block) at Brent Road (circle), Potomac, Maryland

Date: 4/30/97 Time Period: 2:00-3:30 p.m. Weather/Road Conditions: Sunny, 70-75^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to Beginning of Circle: 523 feet

Western Edge of Circle to Eastern Edge: 58 feet

Eastern Edge of Circle to Ending Point: 404 feet

Total Test Course: 985 feet

TEST TIMING/SPEED DATA

Speed at Starting Point B: 33 mph

Lowest Speed at Traffic Circle: 13 mph

Time to Traverse Traffic Circle: 2.5 seconds

Speed at Ending Point: 32 mph

Time from Starting Pt. B to Ending Point: 23.5 seconds

TRAFFIC CIRCLE TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 10B Unit # A248 Unit Weight: 14,850 lbs. Unit Dimensions: 25'5" (L) 9'2" (W) 9'2" (H)

Test Site: Brickyard Road (8700-8800 block) at Brent Road (circle), Potomac, Maryland

Date: 4/30/97 Time Period: 2:00-3:30 p.m. Weather/Road Conditions: Sunny, 70-75^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to Beginning of Circle: 523 feet

Western Edge of Circle to Eastern Edge: 58 feet

Eastern Edge of Circle to Ending Point: 404 feet

Total Test Course: 985 feet

TEST TIMING/SPEED DATA

Speed at Starting Point B: 36 mph

Lowest Speed at Traffic Circle: 13 mph

Time to Traverse Traffic Circle: 2.3 seconds

Speed at Ending Point: 39 mph

Time from Starting Pt. B to Ending Point: 22.4 seconds

TRAFFIC CIRCLE TEST COMPOSITE DATA SHEET

GENERAL TEST DATA

Test # 10C Unit # A248 Unit Weight: 14,850 lbs. Unit Dimensions: 25'5" (L) 9'2" (W) 9'2" (H)

Test Site: Brickyard Road (8700-8800 block) at Brent Road (circle), Potomac, Maryland

Date: 4/30/97 Time Period: 2:00-3:30 p.m. Weather/Road Conditions: Sunny, 70-75^0 F, light winds, dry pavement

DISTANCE DATA

Starting Point B to Beginning of Circle: 523 feet

Western Edge of Circle to Eastern Edge: 58 feet

Eastern Edge of Circle to Ending Point: 404 feet

Total Test Course: 985 feet

TEST TIMING/SPEED DATA

Speed at Starting Point B: 36 mph

Lowest Speed at Traffic Circle: 16 mph

Time to Traverse Traffic Circle: 2.2 seconds

Speed at Ending Point: 40 mph

Time from Starting Pt. B to Ending Point: 21.4 seconds

APPENDIX J

TEST VEHICLE SPECIFICATIONS

Unit #	Weight[y] (lbs)	Dimensions (L,W,H)
Truck 10[z]	54,200	55'10" X 9'10" X 11'4"
Tower 6[aa]	50,750	46'3" X 9'3" X 10'3"
Engine 301[bb]	37,900	30'5" X 8' X 9'3"
Ambulance 248[cc]	14,850	25'5" X 9'2" X 9'2"

Note 1: Width is measured from side mirror to side mirror

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[y] Weight of vehicle and equipment, as measured on Maryland State Police portable scales

[z] 1987 Seagrave 100' aerial ladder, tractor-drawn, rear tiller

[aa] 1989 Sutphen 100' aerial tower

[bb] 1986 Seagrave pumper, with 750 gallon tank

[cc] 1996 Freightliner ambulance

APPENDIX K

RESULTS OF SPEED HUMP AND TRAFFIC CIRCLE TESTS CONDUCTED IN OTHER U.S. CITIES

APPENDIX K-1
BUREAU OF TRAFFIC MANAGEMENT
PORTLAND OFFICE OF TRANSPORTATION
CITY OF PORTLAND, OREGON, JANUARY 1996

TYPICAL IMPACTS OF 14-foot SPEED BUMPS ON EMERGENCY VEHICLES

VEHICLE	LOWEST SPEED (mph)	DESIRABLE SPEED (mph)	TRAVEL TIME DELAY (seconds)	IMPACT DISTANCE (feet)
Engine 18	13	25	2.3	236
	13	30	3.7	399
	13	35	5.2	581
	13	40	7.7	814
Rescue 4 (a)	17	25	1.0	147
	17	30	1.7	269
	17	35	2.9	483
	17	40	4.9	628
Squad 1	12	25	2.7	244
	12	30	4.1	436
	12	35	5.9	611
	12	40	8.3	852
Truck 1 (b)	11	25	3.4	269
	11	30	4.9	455
	11	35	6.6	646
	11	40	9.4	931
Truck 4 (c)	12	25	3.4	315
	12	30	4.9	485
	12	35	6.8	732
	12	40	9.1	1053
Truck 41 (d)	12	25	3.5	327
	12	30	4.7	472
	12	35	6.6	762
	12	40	8.6	1152

Lowest Speed: This is the lowest speed a vehicle travels when crossing a 14-foot speed bump.

Desirable Speed: This is the speed a driver might wish to travel if there were no speed bumps.

Travel Time Delay: This is the additional time required to travel to a destination due to a 14-foot speed bump's influence.

Impact Distance: This is the length of street where a given vehicle cannot be driven at the desired speed because of the speed bump's influence.

a = Ambulance

b = 100 ft. aerial tower

c = 100 ft. tractor-drawn with tiller

d = 100 ft. rear-mount

oregonsp

APPENDIX K-1
BUREAU OF TRAFFIC MANAGEMENT
PORTLAND OFFICE OF TRANSPORTATION
CITY OF PORTLAND, OREGON, JANUARY 1996

TYPICAL IMPACTS OF TRAFFIC CIRCLES ON EMERGENCY VEHICLES

VEHICLE	LOWEST SPEED (mph)	DESIRABLE SPEED (mph)	TRAVEL TIME DELAY (seconds)	IMPACT DISTANCE (feet)
Engine 18	14	25	2.8	261
	14	30	4.3	489
	14	35	6.1	671
	14	40	8.5	814
Rescue 41 (a)	16	25	1.3	170
	16	30	2.3	301
	16	35	3.1	467
	16	40	5.1	612
Squad 1	17	25	1.2	172
	17	30	2.3	326
	17	35	3.7	501
	17	40	5.3	776
Truck 1 (b)	10	25	4.8	319
	10	30	6.4	524
	10	35	8.4	749
	10	40	10.7	1034
Truck 4 (c)	11	25	4.3	322
	11	30	6.2	549
	11	35	8.1	799
	11	40	10.3	1139
Truck 41 (d)	11	25	3.9	338
	11	30	5.2	555
	11	35	7.3	845
	11	40	9.2	1255

Lowest Speed: This is the lowest speed a vehicle travels when navigating around a traffic circle.

Desirable Speed: This is the speed a driver might wish to travel if there were no traffic circles.

Travel Time Delay: This is the additional time required to travel to a destination due to traffic circle's influence.

Impact Distance: This is the length of street where a given vehicle cannot be driven at the desired speed because of the traffic circle's influence.

a = Ambulance

b = 100 ft. aerial tower

c = 100 ft. tractor-drawn with tiller

d = 100 ft. rear-mount

APPENDIX K-2

AUSTIN FIRE DEPARTMENT TEST DATA RESULTS FOR SPEED HUMP EFFECTS ON RESPONSE TIME FOR RICHCREEK ROAD

RANKING OF AVERAGE TIME PER HUMP FOR ALL APPARATUS

Avg. Time Per Hump	Test	Unit	Driver	Hump # 1	Hump # 2	Hump # 3	Hump # 4	Hump # 5	Finish Line	Delay *
1.81	DD	A02	1	3.06	12.36	24.57	34.62	45.63	54.35	9.01
2.24	DD	E18	2	2.97	12.31	23.65	38.13	47.26	56.13	10.79
2.26	DD	A02	Avg.	3.22	13.27	25.80	36.48	47.61	56.23	10.89
2.72	DD	A02	2	3.38	14.17	27.02	38.34	49.59	58.10	12.76
2.83	DD	E18	Avg.	3.56	13.88	26.13	39.69	50.22	59.86	14.52
2.98	DD	T8	2	3.88	15.43	28.52	41.10	51.12	60.06	14.72
2.99	DD	T8	Avg.	3.83	15.60	28.67	40.77	51.14	59.75	14.41
3.01	DD	T8	1	3.78	15.88	28.81	40.43	51.15	59.44	14.10
3.04	15	E18	2	3.13	14.34	27.40	39.12	50.62	59.54	14.20
3.42	DD	E18	1	4.15	15.44	28.61	41.25	53.18	63.58	18.24
3.69	15	E18	Avg.	3.18	15.84	28.69	41.14	53.29	62.37	17.03
4.35	15	E18	1	3.22	17.33	29.97	43.15	55.95	65.19	19.85
4.54	<15	A02	1	3.78	16.86	31.63	44.20	57.29	67.50	22.16
4.56	<15	A02	Avg.	3.85	16.33	30.54	42.65	57.41	65.18	19.84
4.57	<15	A02	2	3.91	15.79	29.45	41.09	57.53	62.85	17.51
9.50	TP	A02	2	4.35	20.87	41.20	58.60	77.67	93.94	48.60
9.67	TP	A02	Avg.	4.79	20.96	41.27	59.60	78.80	94.30	48.96
9.84	TP	A02	1	5.22	21.04	41.34	60.59	79.93	94.66	49.32

* Difference between TCD and non-TCD test course times.

DD = Driver Discretionary Speed
TP = Transport of Patient (simulated)
15 = 15 mph
A02 = Ambulance
E18 = Engine
T8 = 100 ft. Tower Ladder Truck